REMARKS

This Amendment is being filed in response to the Office Action mailed on December 16, 2005. All objections and rejections are respectfully traversed.

Amendments to the Specification

The Specification has been amended to correct an obvious error in calculation. No new subject matter has been introduced.

Amendments to the Claims

Claims 1-39 are pending in the application. Claims 1, 22, 24, 25, 37, and 39 are independent claims. Independent claims 1, 22, 24, 25, 37 and 39 and have been amended to recite that the monitoring of state of charge may occur "*at least when the storage unit is being charged or discharged.*" *See* Specification, page 9, line 9-11 and page 14, lines 14-18. The remainder of the amendments to claims 1-7, 9-15, 17, 21-26, 28, 29, 31 and 33-39 have been made to clarify the claims, and are not intended to narrow the scope of the claimed invention. No additional matter has been added.

Claims 1-39 have been rejected under 35 U.S.C. 102(b) as being anticipated by Chen et al., U.S. Patent No. 6,008,623, issued on December 28, 1999 ("Chen"), or alternatively, by Anzawa, et al., U.S. Patent No. 6,373,223, issued April 16, 2002 ("Anzawa").

Briefly, the present invention teaches a system and analogous method for balancing ***state of charge*** among plural series connected electrical energy storage units. Specifically, individual storage units are selectively accessed by semiconductor switches for monitoring and balancing state of charge. When the state of charge of a selected unit is greater than a target state of charge, energy is transferred from the selected unit to the string of storage units, such that the state of charge of the selected unit converges toward the target state of charge.

One embodiment of the present invention as set forth in independent claim 1, as amended, comprises:

> A system for balancing state of charge among a string of plural series connected electrical energy storage units, comprising:

> a string of electrical energy storage units, each storage unit having a state of charge;
>
> a circuit configured ***to selectively monitor the state of charge*** of each storage unit ***at least when a storage unit is being charged or discharged***, and to transfer energy from a selected storage unit to the string of storage units when the state of charge of the selected storage unit is greater than a target state of charge to converge the state of charge of the selected storage unit toward the target state of charge.

As exemplified in claim 1, the present invention claims a system and analogous method for balancing "***state of charge.***" As described at Pages 9 and 10 of the Specification, the term "state of charge" refers to a measure that characterizes electrochemical states of a cell after a charging or discharging process. State of charge refers to the quantity of charge present in a cell at a given moment as a fraction of the total charge the cell is able to store. Since cell state of charge reflects the electrochemical state, it is important to equalize a cell's state of charge in order to enhance cell life and cell safety.

Equalization of cell *terminal* voltage as practiced in the prior art differs significantly from equalization of "state of charge." In prior art techniques, the readily accessible cell terminal voltage is measured and used as an indicator of cell equalization. However, simply measuring cell terminal voltage in order to equalize cells has drawbacks, because cells having the same terminal voltage may not have the same state of charge.

Cell terminal voltage provides an unreliable measure of state of charge when the string of cells is either providing current to an external load (e.g., hybrid electric vehicle motor) or receiving current from a charging source (e.g., vehicle motor acting as a generator to provide braking action). If the cell string is at rest and neither supplying load current or receiving charging current then cell terminal voltage is equal to cell *internal* voltage which can be used to assess state of charge. However, when cell string load or charging current is flowing, the terminal voltage is lower or higher than the cell internal voltage respectively because of voltage developed across the cell impedance due to the load or charging current flow through it. If two cells have identical state of charge but different impedances, the cells will manifest different terminal voltages when load or charging current is present. If a cell balancing system then equalizes those terminal voltages, it will create an imbalance in the state of charge where one did not previously exist. Because quite small voltage differences correspond to very significant state

of charge differences, failure to correct for impedance effects can produce large cell balancing errors. Therefore, the use of "state of charge" accounts for the internal impedance of cell, allowing for cell balancing during charging and discharging conditions which prevail in practical applications, e.g., equalization of cells in a hybrid electric vehicle or laptop computer battery pack.

According to particular embodiments of the invention, both cell terminal voltage and cell current are measured under load to enable computation of compensation for the current induced voltage drop or rise across the cell impedance. The state of charge may then be equalized by correcting for the voltage difference that is due to the load and impedance differences and then comparing voltages of individual cells. Thus, while embodiments of the present invention may perform cell equalization while the string of cells is at rest, it may also perform equalization while cells are charging or discharging.

Independent claims 1, 22, 24, 25, 37 and 39 all recite limitations to the monitoring and equalization of state of charge while storage units are being charged or discharged.

Chen teaches a battery charge equalizer for voltage equalizing with multiple flyback converters for each battery in a series of connected battery strings.

Anzawa teaches a voltage equalizing apparatus using a multi-secondary transformer and a flyback converter with a plurality of secondary windings for each battery in a series of connected battery strings.

I. The Rejections Under 35 U.S.C. 102(b)

Claims 1-39 were rejected under 35 U.S.C. 102(b) as anticipated by Chen or Anzawa.

A. Chen et al. and the Present Invention

The Examiner has cited Chen, without specific reference, as disclosing a "charge equalizer having, *inter alia*, a plurality of cells, a monitoring means for tracking the charge in each cell, and a micro controller for transferring charge away and/or to the cells. Bi-directional switches and transformers are selected to perform the charge transformer."

As stated above, the present invention teaches a method and system for balancing ***state of charge***. Applicants respectfully submit that Chen does not recognize the monitoring of the state of charge, and would not provide the balancing of state of charge as intended by the present

invention. Chen teaches the use of "battery voltage sensing circuits" for equalization of cell voltage. *See* Col. 4, lines 24 – 44, Col. 5. lines 3-22. The present invention's use of state of charge improves upon the use of a mere voltage measurement. Chen makes no mention of state of charge, and fails to take into account the internal impedance of the battery cells in equalization. As discussed above, measurement of battery voltage as performed by Chen is not the same as a determination of state of charge, and would not be sufficient for proper equalization under a charging or discharging condition.

Further, with respect to various dependent claims relating to bidirectional switching (for example, claims 2-5, 7, 9-17, 23, 24, 26-31, 34-36, 38 and 39). Chen provides the transfer of charge away from a single cell to the string of cells, and not from the string of cells to an individual cell.

B. Anzawa et al. and the Present Invention

Similarly, the Examiner has cited Anzawa, without specific reference, as disclosing a "charge equalizer having, *inter alia*, a plurality of cells, a monitoring means for tracking the charge in each cell, and a micro controller for transferring charge away and/or to the cells. Bi-directional switches and transformers are selected to perform the charge transformer."

Applicants respectfully submit that Anzawa does not recognize the claimed invention of ***monitoring the state of charge***, and would not provide the balancing of state of charge as intended by the present invention. As mentioned above, Anzawa relates to voltage equalization, where the string of cells are either charged or discharged together. The equalization of voltage as performed by Anzawa is not the same as an equalization of state of charge. Under a charging or discharging condition, voltage measurements may be affected. Notably, Anzawa states that equalization is preferably not performed during bulk charge or discharge. Col. 10, lines 41-49. However, as discussed above, the use of a state of charge measurement in the present invention allows for equalization under a charging or discharging condition.

In addition, Anzawa teaches a circuit topology that does not specifically monitor ***each storage unit***. Rather, Anzawa mentions a "means for detecting the variation in the output voltages of the plurality of battery devices." In Anzawa, it appears that the distribution of equalizing charge is determined in an uncontrolled passive sense only by the differences in cell

terminal voltages and those induced in corresponding secondary windings of the multi-winding transformer; there is no control of individual secondary winding voltages with would enable selective control of cell charging or discharging to promote equalization. Col 4, lines 52- 57. Therefore, Anzawa does not provide a means to monitor the individual cells in relation to a ***target state*** of charge (or any target) as claimed by the present invention. Unlike Anzawa, the present invention monitors each storage unit and provides means to control the equalization charging or discharging of each cell.

Applicants respectfully submit that Claims 1-39 are not anticipated by either Chen or Anzawa and thus are in condition for allowance.

Information Disclosure Statement

Information Disclosure Statements (IDS) were filed on July 1, 2004 and October 10, 2004. A Supplemental IDS is being filed concurrently herewith. Entry of the IDSs is respectfully requested.

CONCLUSION

In view of the above amendments and remarks, it is believed that all claims are in condition for allowance, and it is respectfully requested that the application be passed to issue. If the Examiner feels that a telephone conference would expedite prosecution of this case, the Examiner is invited to call the undersigned.

Respectfully submitted,

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Dated: 4/20/06